Adaptation

Climate change scenario planning: A tool for managing parks into uncertain futures

By Don Weeks, Patrick Malone, and Leigh Welling

The challenge of a changing climate

National Park Service Director Jon Jarvis stated in a recent interview that climate change is "the greatest threat to the integrity of the National Park System (NPS) that we've ever faced" (The BigOutside Blog 2010). Global temperatures are rapidly rising. The National Oceanic and Atmospheric Administration (2011) has announced that for the entire planet, 2010 is the hottest year on record, tied with 2005. And the period 2001 to 2010 is the hottest decade on record for the globe (fig. 1).

Rising temperatures will influence many aspects of Earth's hydrologic systems, such as precipitation, snow, ice, and permafrost, which will in turn affect plant and animal life and processes such as fire. These cascading effects are already impacting the natural and cultural resources the National Park Service is charged to protect. The range of impacts land managers will need to address are unprecedented and most are not well understood. There is much uncertainty about the specific ways in which ecosystems, populations, and species will respond to these changes.

Over the last several years, there has been renewed commitment in the federal government to addressing the important issue of climate change. The National Park Service, in particular, is looking at new ways to think about, and plan for, the effects of climate change. In fall 2010, the National Park Service published its *Climate Change Response Strategy*, which outlines a broad framework for how the agency will address climate change. Planning for climate change within an adaptation framework is a cornerstone of that document. But even before that, the Service had been quietly exploring and testing ways to plan more effectively in this dynamic environment.

Planning with uncertainty

Forecast vs. scenario planning
The NPS Park Planning Program Standards (Director's Order 2.0) were released in 2004 as the new planning road map for park management. This framework represents a series of planning elements, starting with a Foundation Statement that identifies the fundamental resources and values a park is committed to preserving and maintaining based on legislation. These priorities are then carried through the remaining planning framework.
The next planning element, the General Management Plan (GMP), defines *desired conditions* for park-specific fundamental resources and values and identifies the preferred alternative for park management to follow. In the idealized framework, the GMP is followed by a Resource Stewardship Strategy (RSS), which quantifies the desired conditions so that park management has measurable targets for establishing specific management goals and generates strategies to achieve them. These strategies then feed into the park's five-year Strategic Plan, which reflects a prioritization of action items the park commits to implement. This approach is one of forecast planning and it is based on expectations for the future, as park management follows a preferred management alternative for the next 15 to 20 years (fig. 2a).

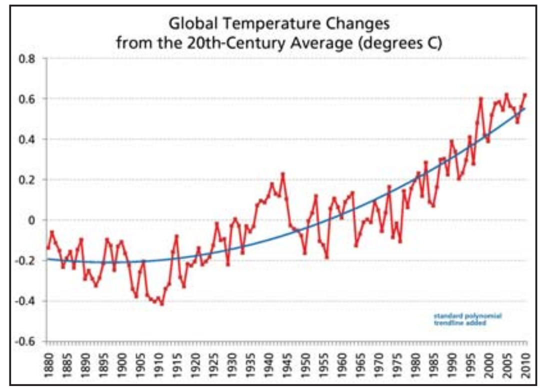


Figure 1. Global temperature changes from the 20th-century average (NOAA 2011).

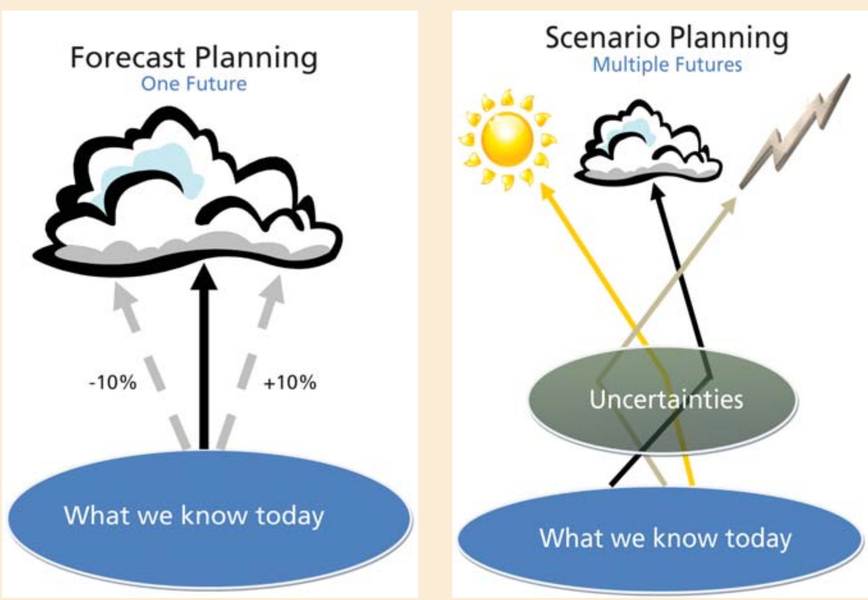
When considering a changing climate in park planning, the forecast approach is limited by incomplete knowledge of highly consequential factors that are largely unpredictable and outside of management control but influence a park's future conditions. The far-reaching effects of climate change, coupled with high uncertainty about local impacts, produce a range of plausible futures (constrained by the best available science), to which park managers will have to react (fig. 2b). How does the National Park Service identify what future, or potential futures, to plan for? What are the best response options when faced with a range of potential climate futures? These are not easy questions. Exploring the potential consequences of climate change can lead to management paralysis or, if structured correctly, can stimulate new ways of thinking and planning.

Scenario planning
Scenario planning is a process designed for managing into futures with high uncertainty and lack of control (fig. 3). Scenario planning was developed during the Cold War as a way for the United States to

Abstract

Climate change presents unprecedented challenges for the National Park Service (NPS), as science reveals a range of potential climate futures faced by land managers. Such climate-related influences as increases in air temperature; sea-level rise; and changes in precipitation, wind speed, and extreme weather events test traditional park planning and management as parks move toward these uncertain futures. In traditional park planning, a preferred alternative is selected for park management to follow for the next 15 to 20 years, and management works toward that desired outcome. Today, in a world of climate change, new planning processes are needed to manage into uncertain futures. We describe the process of scenario planning, which the NPS Climate Change Response Program is exploring as a tool for park planning and management in an era of uncertainty. We discuss park-specific experiences gained over the past three years from the exploration and application of climate change scenario planning in which managers are presented with a series of plausible futures. Since 2008, the National Park Service has completed five case studies to test the use of climate change scenario planning, with favorable reaction. Under guidance of the Global Business Network, an international pioneer in the evolution and application of scenario planning, the National Park Service has begun to focus on educating its staff and partners on the utility of climate change scenario planning through several training workshops to better assist in its landscape adaptation efforts and other management responses.

Key words: adaptation, climate change, climate variables, impacts, scenario planning

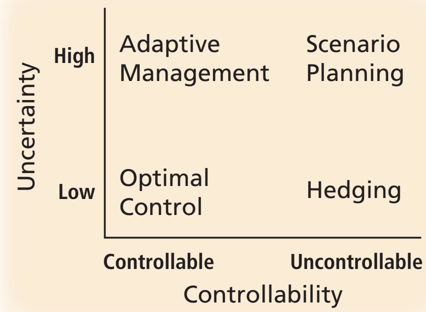


GLOBAL BUSINESS NETWORK (2)

Figure 2. Forecast planning (*a*, at left) vs. scenario planning (*b*, at right).

analyze the relationship between Soviet weapons development and U.S. military strategy (Kahn 1960). The planning approach caught on in the corporate world, starting with Royal Dutch/Shell in the 1970s, and has since led companies from many different industries, such as Microsoft, Nissan, and United Parcel Service, to use scenario planning as a tool for managing into uncertain economic, social, and political futures.

Scenario planning is not a technique for predicting the most probable future. Rather, the objective is to develop and test decisions under a variety of plausible futures. Doing this proactively, essentially rehearsing for multiple futures, strengthens an organization's ability to recognize, adapt to, and take advantage of changes over time (Global Business Network 2009). As such, scenario planning was selected by the National Park Service as a tool to explore for managing parks into a future of climate uncertainty.



PETERSON ET AL. 2003

Figure 3. Appropriate management responses based on uncertainty and controllability.

Climate change scenario planning in the National Park Service

History

In 2006 the National Park Service began exploring the use of scenario planning in the context of climate change. Over a three-year period, the Service and several partners held workshops to evaluate the utility of a scenario-building technique for helping managers to explore the key uncertainties and park impacts related to climate change and begin to evaluate the most appropriate and effective response strategies. Participants completed five case studies during this exploration phase at Joshua Tree National Park (California), Kaloko-Honokōhau National Historical Park (Hawaii), Assateague Island National Seashore (Maryland), and Wind Cave (South Dakota) and Glacier (Montana) national parks. While several of the case

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studies considered the broader landscape within which parks are located, the Glacier National Park workshop explicitly examined the use of climate change scenario planning in the larger Crown of the Continent ecosystem, which is the transboundary landscape of Waterton-Glacier International Peace Park and more than 20 other state, provincial, and tribal governments in this U.S.-Canadian transboundary region. For each of the five case studies, managers developed several potential climate futures using recent climate data along with model projections, and then evaluated these futures in the context of management challenges and options. Partners involved in this investigative work were the National Interagency Fire Center, the National Center for Landscape Fire Analysis at the University of Montana, the USGS Northern Prairie Wildlife Research Center, the NOAA-funded Climate Assessment for the Southwest at the University of Arizona, and the Global Business Network (GBN).

Building from the favorable reactions and lessons learned during the case studies, the National Park Service teamed with the Global Business Network, a pioneer in the evolution and application of scenario planning, to begin the next phase of scenario planning in 2010. This second stage focused on raising awareness of and building capacity in the scenario planning process within and outside the National Park Service, as well as exploring how scenario thinking may complement landscape adaptation and long-range planning. Thus the National Park Service completed four training workshops in 2010–2011, each focusing on specific bioregional landscapes.

Workshop 1: Alaska's Arctic and Coastal bioregions (Anchorage, Alaska, August 2010)

Workshop 2: Great Lakes and Atlantic Coast bioregions (Duluth, Minnesota, October 2010)

Workshop 3: Urban Landscapes and Eastern Forests bioregions (Shepherdstown, West Virginia, December 2010)

Workshop 4: Western Mountains, Pacific Islands, and Arid Lands (Denver, Colorado, February 2011)

These workshops introduced approximately 150 participants to the climate change scenario planning process. The disciplines of the participants ranged from climate change science, to natural and cultural resources and facilities management, to education, planning, and interpretation, and included a variety of land management agencies.

Basic steps

So what is the process for climate change scenario planning? The first step is assembling an interdisciplinary core team to design, facilitate, and bring in the appropriate climate science and management expertise for the planning exercise. According to GBN, participants should include *knowledge holders*, *stakeholders*, and the *curious and creative*. More specifically for the National Park Service planners, educators, scientists, natural and cultural resource managers, facility managers, superintendents, and partnership coordinators, along with representatives from other jurisdictions within the landscape, have important voices in the process.

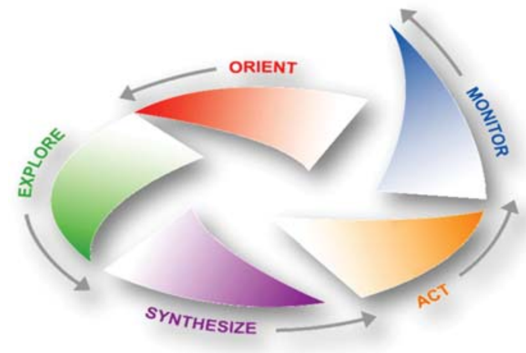

Figure 4. Scenario creation five-step process.
GLOBAL BUSINESS NETWORK 2011

With a variety of approaches available for scenario development, an approach practiced by GBN and applied to the NPS training can be divided into five steps, illustrated in figure 4. These steps resemble a basic adaptive management process and provide a solid framework for NPS scenario planning that is familiar to park managers.

1. ***Orient***: Define the strategic issue and the scale at which to address it. This is framed as a focal question, such as "How will climate change effects impact the landscapes within which management units are located over the next 50 to 100 years?" or "How can managers best respond to long-term change over a 20-year planning horizon?"

2. ***Explore***: Identify the driving forces and major effects that influence the future of the focal question. For climate change scenario planning, a climatologist is engaged to synthesize current science and create a list of relevant climate variables (e.g., temperature, precipitation, storm frequency) along with the projected trend and confidence for

Table 1. Summary of projected climate changes for Alaska

Climate Variable	General Change Expected	Specific Change Expected and Reference Period	Size of Expected Change Compared to Recent Changes	Patterns of Change	Confidence	Source and Context
Temperature	Increase	2050: +3°C ± 2°C 2100: +5°C ± 3°C	Large	More pronounced in north and in autumn-winter	>95% (sign) Very likely	IPCC 2007, SNAP 2010
Precipitation	Increase	2050: 10–25% ± 15% 2100: 20–50% ± 20%	Large	Greater overall percentage increase in north	>90% (sign) Very likely	IPCC 2007, SNAP 2010
Relative humidity	Little change	2050: 0% ± 10% 2100: 0% ± 15%	Small	Absolute humidity increases	50% About as likely as not	SNAP 2010
Wind speed	Increase	2050: +2% ± 4% 2100: +4% ± 8%	Small	More pronounced in winter and spring	>90% (sign) Likely	Abatzoglou and Brown[1]
Pacific Decadal Oscillation (atmospheric circulation)	Decadal to multi-decadal circulation anomalies affecting Alaska	Unknown	Large (comparable to climatic jump in 1970s)	Major effect on Alaskan temperatures in cold season	Natural variation, essentially unpredictable	Hartmann and Wendler 2005
Extreme events: Temperature	Warm events increase, cold events decrease	2050: increase 3–6 times over present conditions for warm events; decrease 1/5–1/3 of present conditions in cold events 2100: increase 5–8.5 times present conditions in warm events; decrease 1/12 to 1/8 present conditions in cold events	Large	Increase in frequency and duration of extreme hot events, decrease in extreme cold events (winter)	Modeled and observed Very likely	Abatzoglou and Brown[1], Timlin and Walsh 2007
Extreme events: Precipitation	Decrease/Increase	2050: −20% to +50% 2100: −20% to +50%	Large	Increase in frequency and contribution, especially in winter	Modeled and observed Uncertain	Abatzoglou and Brown[1]
Extreme events: Storms	Increase	Increase in frequency and intensity	Any increases exacerbated by sea ice reduction and sea-level increase	Increases at southern periphery of Arctic; little information for central Arctic	>66% Likely	Loehman[2] 2007
Sea ice	Decrease	2050: 40–60% loss in Bering Sea (winter/spring); 20–70% loss in Chukchi/Beaufort (summer)	Comparable to recent changes	Nearly ice-free summers by 2050 with ice-free summers by 2100; less loss of sea ice in winter than in summer	>90% Very likely	Wang and Overland 2009
Snow	Increased snowfall during winter, shorter snow season	Winter snowfall 2050: 10–25% 2100: 20–50%	Recent changes not well established	Cold-season snow amounts will increase in interior and north of Brooks Range; increased percentage of precipitation will fall as rain (especially in spring and autumn)	Large uncertainty in timing of snowmelt (warmer springs, more snow to melt)	AMAP 2011
Freeze date (freshwater lakes)	Later in autumn	2050: 10–20 days later near north coast; 5–10 days later elsewhere 2100: 20–40 days later near north coast; 10–20 days later elsewhere	Large		>90% (sign) Very likely	SNAP 2010

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Table 1 (continued)

Climate Variable	General Change Expected	Specific Change Expected and Reference Period	Size of Expected Change Compared to Recent Changes	Patterns of Change	Confidence	Source and Context
Length of ice-free season for rivers and lakes	Increase	2050: 7–10 days longer than present 2100: 14–21 days longer than present	Large	Greatest near coasts where sea ice retreats; open-water season lengthens	>90% Very likely	IPCC 2007, SNAP 2010
River and stream temperatures	Increase	2050: 1–3°C 2100: 2–4°C	Large	Consistent with earlier ice breakup and higher air temperatures	>90% Very likely	Kyle and Brabets 2001
Length of growing season	Increase	2050: 10–20 days longer 2100: 20–40 days longer	Continuation of recent changes	Greatest near coasts	>90% Very likely	IPCC 2007, SNAP 2010
Permafrost	Increased area of permafrost degradation (annual mean temperature > 0°C)	2050: ~100–200 km northward displacement 2100: ~150–300 km northward displacement	Large	Permafrost degradation primarily in area of warm permafrost (southern and interior Alaska)	>90% (sign) Very likely	SNAP 2010, Romanovsky et al. 2010
Sea level	Increase	2050: 3 inches to 2 feet 2100: 7 inches to 6 feet	Large	Large uncertainties, especially at upper end of range; complicated by isostatic rebound, especially in southeastern Alaska	>90% (sign, except in areas of strong isostatic uplift)	IPCC 2007

Source: John Walsh, professor of climate change and chief scientist, International Arctic Research Center, University of Alaska–Fairbanks.

Note: Projected changes are for midrange forcing scenario (A1B). Ranges of projected changes would be wider if low-emission (N2) and high-emission (A2) scenarios were included.

[1]Abatzoglou, J. T., and T. J. Brown. Results extracted from nine climate models from Field et al. 2007 (see references). Values based on SRES A1B. See table 1a: Drivers of external change for Joshua Tree National Park (Loehman 2007, below).

[2]Loehman, R. 2007. Table 1a: Drivers of external change for Joshua Tree National Park. Climate Change Scenario Planning Workshop for Joshua Tree National Park and Kaloko-Honokōhau National Historical Park. 13–15 November. National Park Service, Joshua Tree National Park, California. (Table data synthesized from Field et al. 2007 [see references]).

Table 2. Certainty of climate change variables in Assateague Island National Seashore case study

Climate Variable	Predetermined	Critical Uncertainty
Temperature increase	X	
Precipitation		X
Sea-level rise		X
Drought		X
Snow cover decrease	X	
Extreme events: Storms		X

each (table 1). The ability to synthesize climate data and projections into a form that is both accurate and easily understandable by nonscientists is a critical factor upon which many other steps in the process depend. Once the important variables are identified, they must be understood and ranked within the dual context of "uncertainty" and "importance." The objective is to narrow down the list to those variables that are most important and most uncertain to further explore. A variable that does not meet the criteria of important and uncertain may become a "predetermined" variable that is a factor in all scenarios or may not be considered at all (table 2). It is useful at this stage to explore what kinds of conditions may be associated with the extreme uncertainties of a given variable (e.g., would a 10% increase in precipitation result in very different conditions from a 20% decrease?). The NPS approach also develops a table of known and potential resource impacts during the exploration stage, which is drawn upon in the next step.

3. ***Synthesize***: Participants combine information from select climate variables in a way that allows them to envision

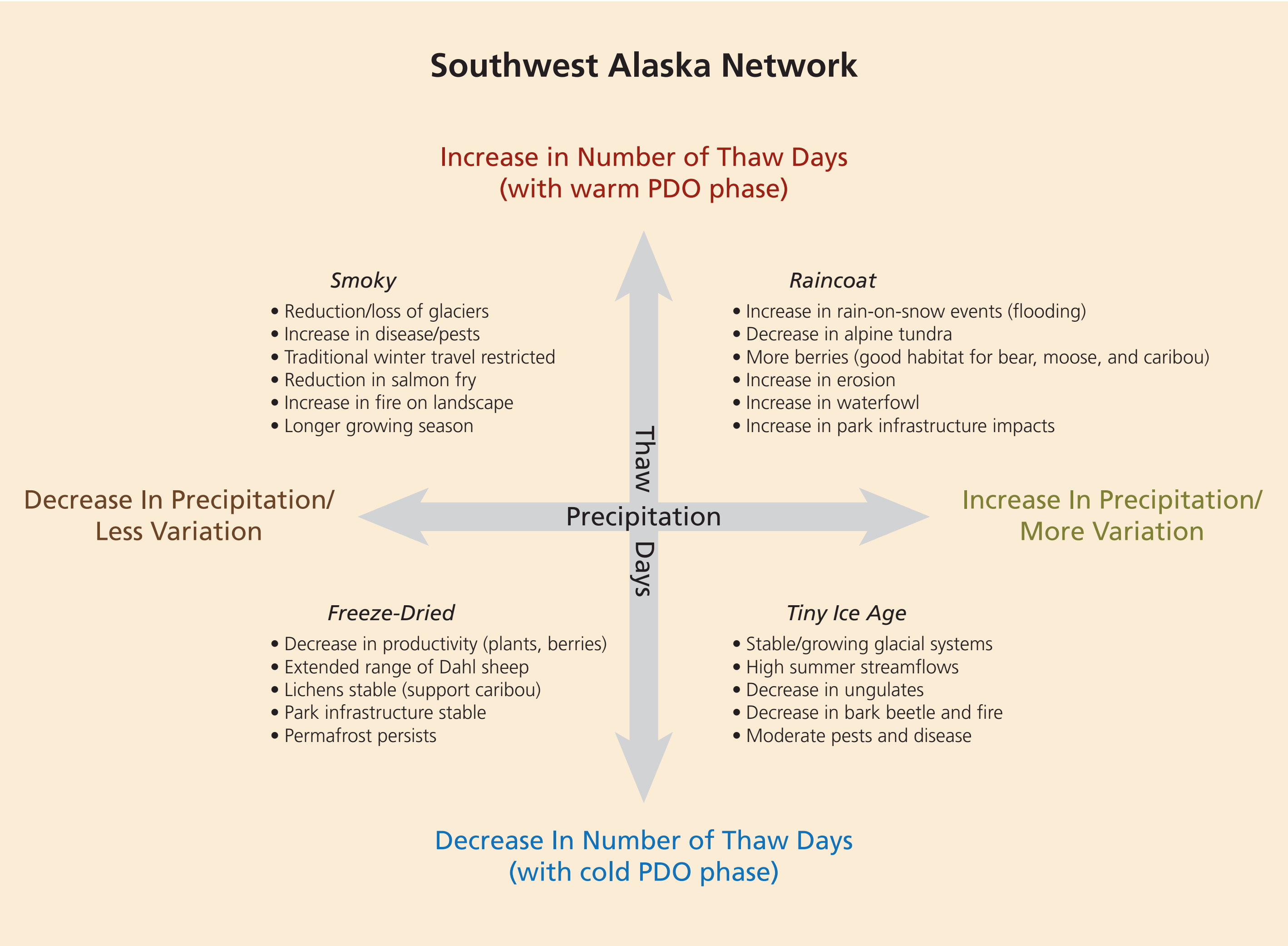

Figure 5. Climate variable framework example from the Southwest Alaska Network workshop. The *x* axis depicts changes in precipitation; the *y* axis shows changes in the number of thaw days per year (above freezing), taking into account the compounding effect of the Pacific Decadal Oscillation (PDO), an oscillating pattern of warm and cool water in the northern Pacific Ocean that shifts about every 20–30 years, influencing air temperatures in Alaska.

different future conditions (scenarios) that may result. We used a 2 × 2 matrix approach with climate variables represented on the axes. For example, *precipitation* and *thaw days* may be selected as two axes for generating four different climate futures (fig. 5). Several scenario matrices can be constructed by trying different combinations of two axes, each generating a set of four scenarios. Selected axes are combined in this way until participants settle on one matrix that best fits the criteria of *plausible*, *divergent*, *relevant*, and *challenging*, which are important for capturing a robust set of scenarios that will allow participants to consider a wide array of potential actions. Once the scenario matrix is selected, participants describe each scenario in detail, using the table of impacts that was created during the exploration phase. The group then identifies the implications of these four climate futures (fig. 5) and the actions needed to respond and adapt.

4. ***Act***: Implement effective management actions. Managers may choose to act on one scenario that appears to represent the most probable future or they may identify several actions that are common to all scenarios (often termed “no regrets” actions). It is also important to identify current practices that are “no gainers” and need to be discontinued. An example of a no-regrets action for southwestern Alaska parks is to improve connectivity across landscapes and jurisdictional boundaries. A no-gainer action at Assateague Island National Seashore, Maryland, would be to build permanent structures on the island despite

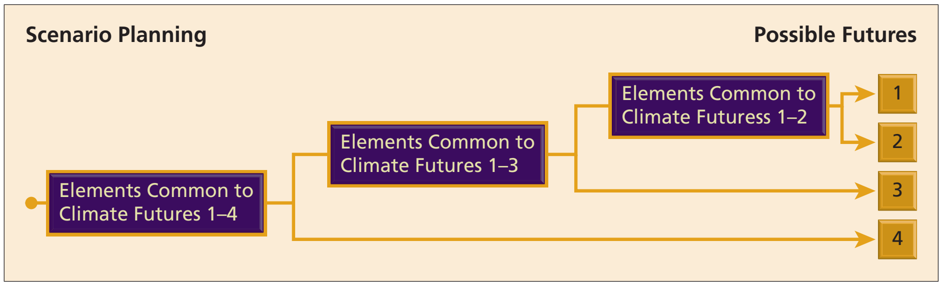

Figure 6. Management through a range of plausible climate futures.

high confidence in a climate future of sea-level rise.

5. ***Monitor***: As new information unfolds, managers should continue to validate the scenarios and evaluate the effectiveness of their response. Is there evidence of moving toward one or a select group of scenarios? Can decisions and actions be adjusted to incorporate new information? While continuing to monitor key indicators, managers should look for signals that a particular scenario is becoming a reality and adjust decisions as necessary (fig. 6).

Nested scenarios: Considering the sociopolitical landscape

The 2 × 2 approach can be used with other types of variables besides climate, such as social, political, and economic variables, which are also uncertain and highly consequential to decision making. When exploring different types of scenario matrices for the same focal question, a method known as "nesting" can be very useful, whereby one matrix is embedded in another. For the NPS-GBN workshops, we created a sociopolitical matrix to describe the broader decision environment within which climate change will manifest, yielding an even broader array of possible futures to consider.

NPS role in climate change response

The National Park Service can, and does, play an important role in the national and global responses to climate change. Protected lands help to conserve biodiversity, support ecosystem adaptation, provide laboratories for fundamental and applied research, and offer many opportunities to engage communities in learning and environmental stewardship (see articles in the "Communication and Public Engagement" section beginning on page 56). Scenario planning is an important tool in the Service's four-pronged Climate Change Response Strategy (i.e., science, adaptation, mitigation, and communication). It allows managers to synthesize the information and potential implications from climate change in a way that is relevant to the conservation of park resources and landscape values.

With its flexible approach to accommodating changing circumstances, scenario planning is one way in which the National Park Service could change its planning paradigm. It is a process that encourages collaboration with other federal land management agencies, climate scientists, and academic institutions. As Director Jarvis said at the conclusion of his interview with The BigOutside Blog (2010), "If there's any silver lining, climate change is forcing us to think and act at the landscape scale. No longer can we think of parks as islands."

Clearly the challenge of managing resources in the face of climate change is daunting. As George Black (2011) points out in a recent magazine article published by the Natural Resources Defense Council, "Adapting to climate change is a singularly complex challenge. It requires money, new technology and infrastructure, institutional capacity, accurate data, different ways of producing and consuming energy, changes in culture and lifestyle, and the nimbleness to adjust to constantly shifting and uncertain circumstances." The National Park Service has made a commitment to addressing these challenges and will continue to take a leadership role in navigating the uncertainties of climate change, exploring and using a variety of scenario planning techniques and other tools to enable effective management response. After all, perpetuity is part of our mission, and that means we are in it for the long haul.

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How does the National Park Service identify what future, or potential futures, to plan for? What are the best response options when faced with a range of potential climate futures? These are not easy questions.

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